國立中山大學 109 學年度
碩士暨碩士專班招生考試試題

科目名稱：基礎熱傳學【機電系碩士班甲組】

1.(10%) The heat flux that is applied to one face of a plane wall is q''=25 W/m². The opposite face is exposed to air at temperature 30℃, with a convection heat transfer coefficient of 25 W/m²·K. The surface temperature of the wall exposed to air is measured and found to be 50℃. Do steady-state conditions exist (5%)? If not, is the temperature of the wall increasing or decreasing with time (5%)?

2. (20%) A computer consists of an array of five printed circuit boards (PBCs), each dissipating P_b = 20 W of power, Cooling of the electronic components on a board is provided by the forced flow of air, equally distributed in passages formed by adjoining boards, and the convection coefficient associated with heat transfer from the components to the air is approximately h = 200 W/m²·K. Air enters the computer console at a temperature of T_i = 20℃, and flow is driven by a fan whose power consumption is P_f = 25 W.

    (a) (10%) If the temperature rise of the airflow, (To - T_i), is not to exceed 15℃, what is the minimum allowable volumetric flow rate $\dot{V}$ of the air? The density and specific heat of the air may be approximated as ρ = 1.161 kg/m³ and c_p = 1007 J/kg·K, respectively.

    (b) (10%) The component that is most susceptible to thermal failure dissipates 1 W/cm² of surface area. To minimize the potential for thermal failure, where should the component be installed on a PCB? What is its surface temperature at this location?
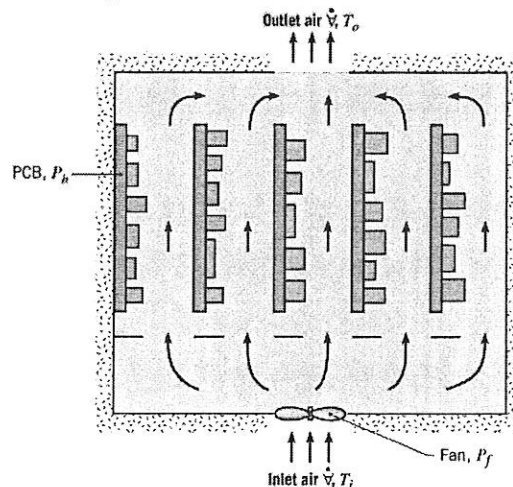
3. (10%) At a given instant of time, the temperature distribution within an infinite homogeneous body is given by the function

$$T(x, y, z) = x^2 - 2y^2 + z^2 - xy + 2yz$$

Assuming constant properties and no internal heat generation, determine the regions where the temperature changes with time.

4. (15%) The temperature distribution across a wall 0.3 m thick at a certain instant of time is

$$T(x) = a + bx + cx^2$$

where T is in degrees Celsius and x is in meters, a = 200℃, b = -200℃/m, and c = 30℃/m². The wall has a thermal conductivity of 1 W/m·K.

    (a) (10%) On a unit surface area basis, determine the rate of heat transfer into and out of the wall and the rate of change of energy stored by the wall.

    (b) (5%) If the cold surface is exposed to a fluid at 100℃, what is the convection coefficient?

5. (10%) Passage of an electric current through a long conducting rod of radius r_i and thermal conductivity k_r results in uniform volumetric heating at a rate of $\dot{q}$. The conducting rod is wrapped in an electrically nonconducting cladding material of outer radius r_o and thermal conductivity k_c, and
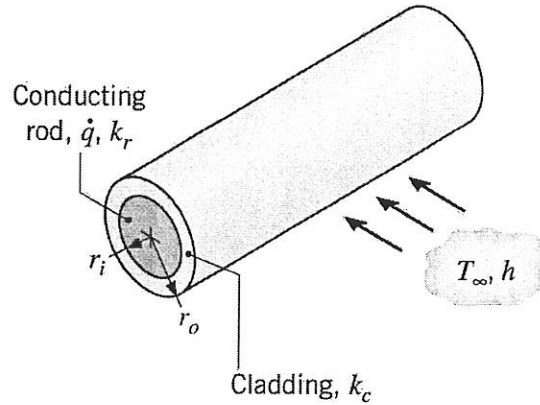
convection cooling is provided by an adjoining fluid. For steady-state conditions, write appropriate forms of the heat equations for the rod and cladding (5%). Express appropriate boundary conditions for the solution of these equations (5%).
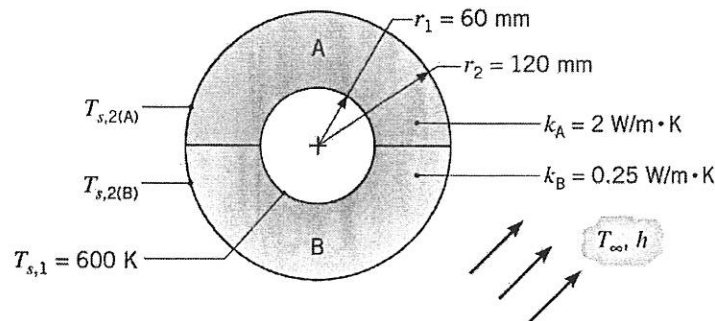

6. (15%) The composite wall of an oven consists of three materials, two of which are of known conductivity, $k_A = 20$ W/m·K and $k_C = 50$ W/m·K, and known thickness, $L_A = 0.30$ m and $L_C = 0.15$ m. The third material, B, which is sandwiched between materials A and C, is of known thickness, $L_B = 0.15$ m, but unknown thermal conductivity k_B. Under steady-state operating conditions, measurements reveal an outer surface temperature of $T_{o,s} = 20°C$, an inner surface temperature of $T_{s,i} = 600°C$, and an oven air temperature of $T_\infty = 800°C$. The inside convection coefficient h is known to be 25 W/m²·K. What is the value of k_B?
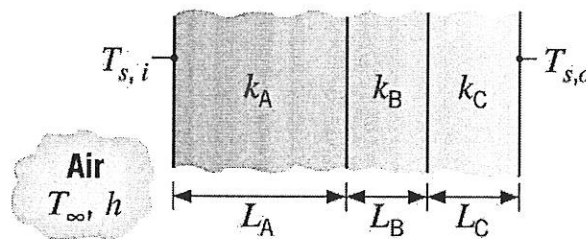
7. (20%) Steam flowing through a long, thin-walled pipe maintains the pipe wall at a uniform temperature of 600 K. The pipe is covered with an insulation blanket comprised of two different materials, A and B. The interface between the two materials may be assumed to have an infinite contact resistance, and the entire outer surface is exposed to air for which $T_\infty = 320$ K and h = 25 W/m²·K.
  (a) (5%) Sketch the thermal circuit of the system. Label all pertinent nodes and resistance
  (b) (10%) For the prescribed conditions, what is the total heat loss from the pipe? (5%) What are the outer surface temperature $T_{s,2(A)}$ and $T_{s,2(B)}$?

國立中山大學 109 學年度
碩士暨碩士專班招生考試試題

科目名稱：工程數學【機電系碩士班乙組、丙組】

1. Solve the following ODEs.
   (a) $2 \cosh x \cos y \, dx = \sinh x \sin y \, dy$ (10%)
   (b) $x^2 y'' - 3xy' + 3y = 3 \ln x - 4$ (10%)

2. Solve the following ODE by using the Laplace transform.
   $y'' + 2y' + 2y = [1 - u(t-2)]e^t - e^2 \delta(t-2), \, y(0) = 0, \, y'(0) = 1.$ (15%)

3. A mixing problem. Each of two tanks contains 200 gal of water, where initially 150 lb (tank T_1) and 100 lb (tank T_2) of salt are dissolved. The inflow into T_1 is 4 gal/min from T_2, and 12 gal/min containing 12 lb of salt from the outside. The inflow into T_2 is 16 gal/min from T_1. The outflow from T_2 is $4 + 12 = 16$ gal/min. The mixtures are kept uniform by stirring. Find the salt contents $y_1(t)$ and $y_2(t)$ in T_1 and T_2, respectively.
   (a) Set up the model. (5%)
   (b) Solve the system. (10%)

4. (a) A line integral with continuous F_1, F_2, F_3 in a domain D in space. Show that the line integral is path independent if $\mathbf{F} \cdot d\mathbf{r}$ is exact in D. (5%)
   (b) If the differential form (a) is exact in D, show that curl $\mathbf{F}=\mathbf{0}$. (5%)

5. Is the given function even or odd or neither even nor odd? Find its Fourier series. Show details of your work. (10%)
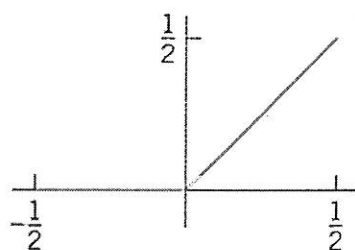

Figure 1.

6. A force $\mathbf{p} = [4, 2, 0]$ is acting in a line through $(2, 3, 0)$. Find its moment vector about the center $(5, 1, 0)$ of a wheel. (5%)

7. The state of stress in the cube is as follows:
   $$\sigma_{ij} = \begin{bmatrix} 20 & 40 & 0 \\ 40 & -40 & 0 \\ 0 & 0 & 5 \end{bmatrix} \text{ (in MPa)}$$
   where $i = 1, 2, 3$
   (a) Determine the principal stresses for the cube. (10%)
   (b) Determine the directions where the principal stresses ocurr. (10%)
   (c) Suppose the compressive/tensile strength of the body are 50 MPa. Does the body fail in the stress state? Explain the reason. (5%)

[Note: Since the stress $\mathbf{\sigma}$ is a symmetric tensor, it has three real eigenvalues σ_1, σ_2, σ_3 called principal stresses, and three corresponding orthonormal eigenvectors called principal directions. The eigenvalue problem can be written as $\mathbf{t^{(n)}} = \mathbf{\sigma n} = \sigma \mathbf{n}$, where $\mathbf{n}$ is a principal direction and σ is a scalar principal stress. Since the traction vector is a multiple of the unit normal, σ is a normal stress component. Thus a principal stress is a stress which acts on a plane of zero shear stress.]

國立中山大學 109 學年度
碩士暨碩士專班招生考試試題

科目名稱：材料力學【機電系碩士班乙組】

---作答注意事項---

考試時間：100 分鐘

- **考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。**請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。

- **答案卷限用藍、黑色筆(含鉛筆)書寫、繪圖或標示**，可攜帶橡皮擦、無色透明無文字墊板、尺規、修正液（帶）、手錶(未附計算器者)。每人每節限使用一份答案卷，不得另攜帶紙張，請衡酌作答。

- 答案卡請以 2B 鉛筆劃記，不可使用修正液（帶）塗改，未使用 2B 鉛筆、劃記太輕或污損致光學閱讀機無法辨識答案者，其後果由考生自行負擔。

- 答案卷（卡）應保持清潔完整，不得折疊、破壞或塗改應考證號碼及條碼，亦不得書寫考生姓名、應考證號碼或與答案無關之任何文字或符號。

- 可否使用計算機請依試題資訊內標註為準，如「可以」使用，廠牌、功能不拘，唯不得攜帶具有通訊、記憶或收發等功能或其他有礙試場安寧、考試公平之各類器材、物品（如鬧鈴、行動電話、電子字典等）入場。

- **試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。**

- **試題採雙面列印，考生應注意試題頁數確實作答。**

- **違規者依本校招生考試試場規則及違規處理辦法處理。**

Prob. #1 (30 %)

（1）　Plot the engineering and true stress-strain diagrams for a ductile material. （10 %，不必依照比例繪製，並請以中文或英文標出圖上各個區域的名稱以及相對應的應力名稱，錯一個扣一分，扣至10分為止）

（2）　以**中文**解釋（或回答）下列名詞（或問題）(20 %)
　　(a)　General state of stress (6 %，請畫出來並標示之，錯一個扣一分，扣至6分為止)
　　(b)　Hooke's law (2 %)（解釋加公式）
　　(c)　Poisson's ratio (2 %)（公式及其範圍）
　　(d)　Homogeneous material (2 %)
　　(e)　Isotropic material (2 %)
　　(f)　Modulus of toughness (2 %)（解釋加圖示）
　　(g)　Saint-Venant's Principle (2 %)
　　(h)　Statically indeterminate problem (2 %)

Prob. #2 (20 %)

Draw the shear and moment diagrams for the following beams. （請清楚標示相關參數及數值、畫出 **V-** 及 **M-Diagram**，不必說明如此標示、畫圖的理由；每小題錯一個扣一分，扣至5分為止）

編號	Beams	F.B.D.
(1) (5%)		A_y=0, A_y=19 kip, M_A=113 kip·ft
(2) (5%)		
(3) (5%)		
(4) (5%)		

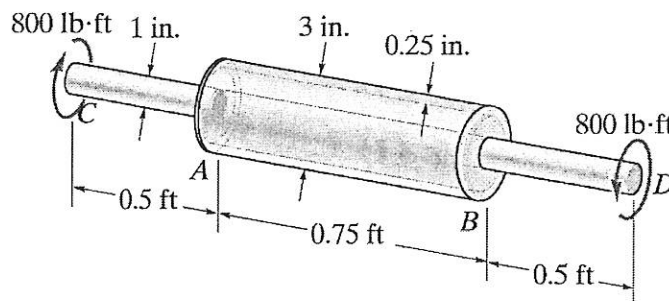試題請隨卷繳回，請留意背面是否有題

Prob. #3 (30 %)

If the supports at *A* and *C* are flexible and have a stiffness *k*, determine the support reactions at *A* and *C*. The material has a modulus of elasticity of *E*. （相關變形量的相對位置的示意圖必須清楚標示出來）
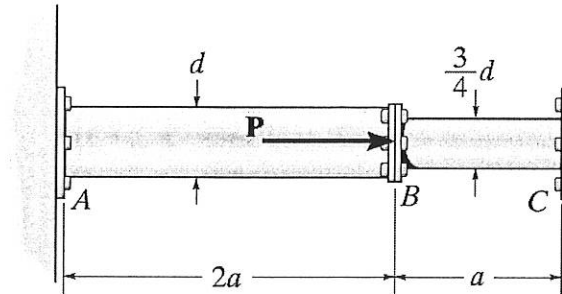
圖一　Prob. #3

Prob. #4 (20 %)

The composite shaft consists of a mid-section that includes the 1-in.-diameter solid shaft and a tube that is welded to the rigid flanges at *A* and *B*. Neglect the thickness of the flanges and determine the angle of twist of end *C* of the shaft relative to end *D*. The shaft is subjected to a torque of 800 lb • ft. The material is A-36 steel, $E_{st} = 29(10^3)$ ksi and $G_{st} = 11(10^3)$ ksi.

圖二　Prob. #4

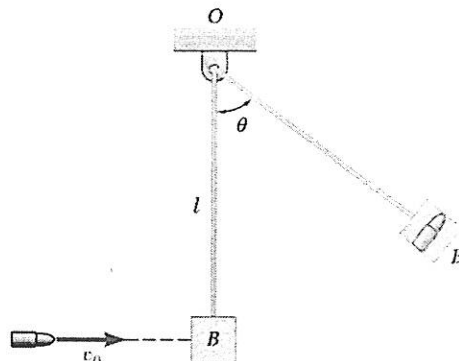# 國立中山大學 109 學年度
碩士暨碩士專班招生考試試題

科目名稱：應用力學(含靜力學及動力學)【機電系碩士班乙組】

1. (20%) A slender rod AB, of weight W, is attached to blocks A and B, which move freely in the guides shown. The blocks are connected by an elastic cord that passes over a pulley at C. Determine the value of θ for which the tension in the cord is equal to 5W.
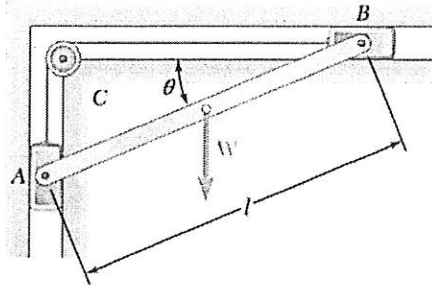
2. (20%) Two **10-N blocks** A and B are connected by a slender rod of negligible weight. **The coefficient of static friction is 0.30** between all surfaces of contact, and the rod forms **an angle θ = 30°** with the vertical. Determine the largest value of P for which equilibrium is maintained.
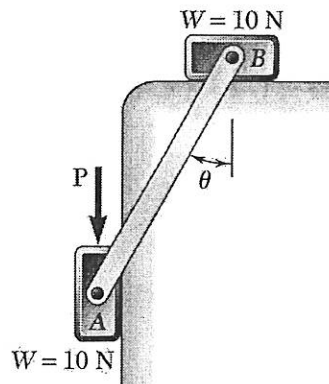
3. (20%) A **6-g bullet** is fired into a **1000-g wood** block B which is suspended by a cord of length **l = 2.2 meter.** The block then swings through **a maximum angle of θ = 60°**. Determine the initial speed of the bullet v_0 and the force on the cord immediately after the impact.

4. **(20%)** Tim throw a Pokeball, assuming <u>a solid sphere of radius r and mass m</u>, along a grass ground as <u>a rough horizontal surface with the initial velocities indicated</u>. If the final velocity of the Pokeball is <u>to be zero</u>, express, in terms of v_0, r, and μ_k. Determine the required magnitude of $\boldsymbol{\omega}_0$, the time t_1 required for the sphere to come to rest and the distance the sphere will move before coming to rest.
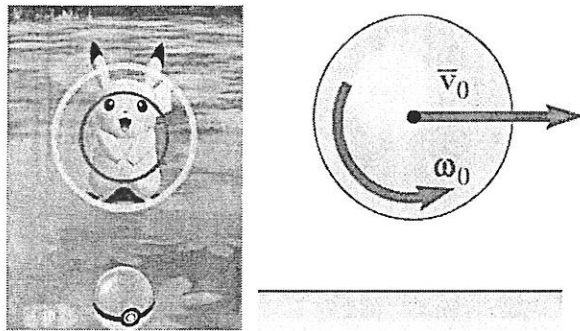
5. **(20%)** A-shin quit from the gymnastics team and joined the local gang. In street fights, he always used learned skills, such as handstand turn, backflip, front handspring and horizontal bar, from the gymnastics team. For example, he would like to kick the trolley to attack a street ruffian as shown in Figs. We assume that A-shin, as a <u>slender rod AB</u>, is released from <u>rest</u> in the <u>horizontal position</u>. He swings down to a <u>vertical position</u> and <u>strikes the trolley</u>, as a second <u>rod CD</u> which is similar to the rod AB. Assuming that the bar CD is <u>resting on a frictionless surface</u> and <u>the coefficient of restitution</u> between the rods is <u>0.4</u>. Determine the velocity of the trolley (rod CD) immediately after the impact.

試題請隨卷繳回，請留意背面是否有題

國立中山大學 109 學年度
碩士暨碩士專班招生考試試題

科目名稱：自動控制【機電系碩士班丙組】

1. (10%) In Fig. 1, if $M = 3, f_v = 2.4, K = 2$, find the percent overshoot and settling time with $f(t)$ as a unit-step input.
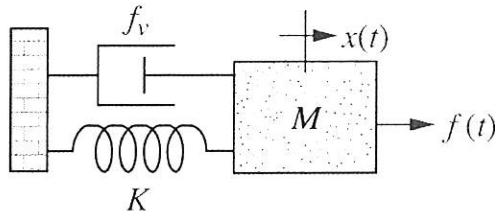

Fig. 1

2. (10%) In Fig. 2, determine the transfer function $V_o(s)/V_{in}(s)$ if $R = 10k\Omega$ and find the unit-step input response.
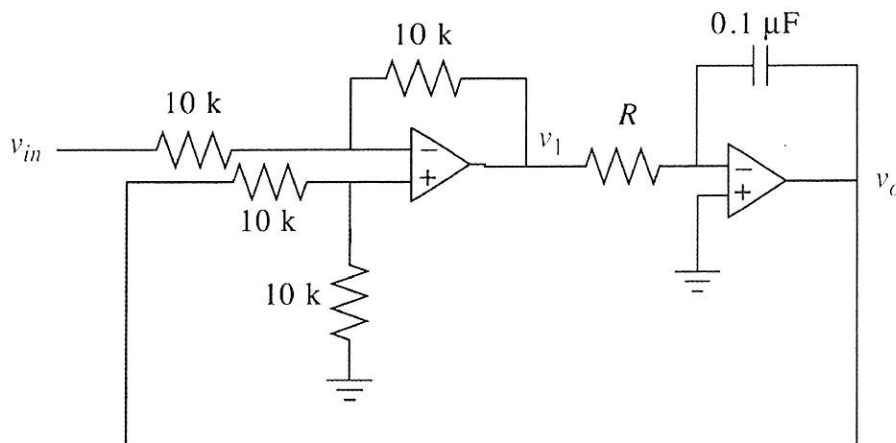

Fig. 2

3. (20%) In Fig. 3, estimate the transfer function $G(s)$. Find the gain margin and phase margin from the bode plots. Also plot the root locus of $G(s)$.
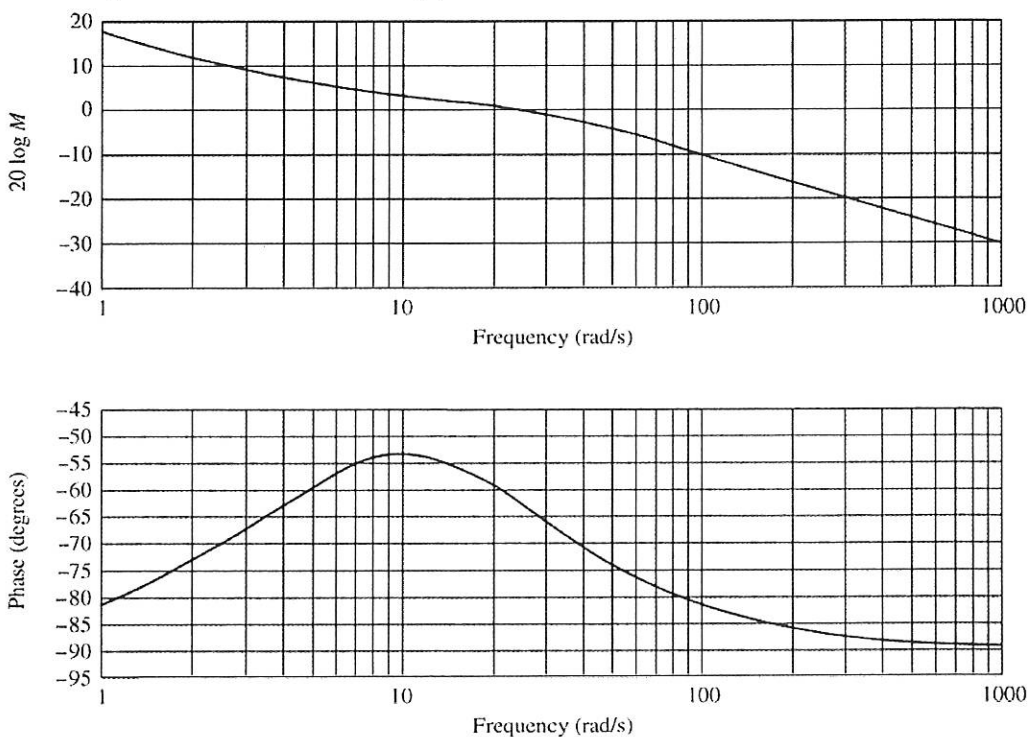

Fig. 3

4. (20%) In Fig. 4, if $G(s) = \dfrac{K(s+2)}{s(s+1)(s^2+20s+200)}$,

　　(a) (5%) plot the root locus;
　　(b) (5%) determine the range of K for stability;
　　(c) (5%) find the asymptotes;
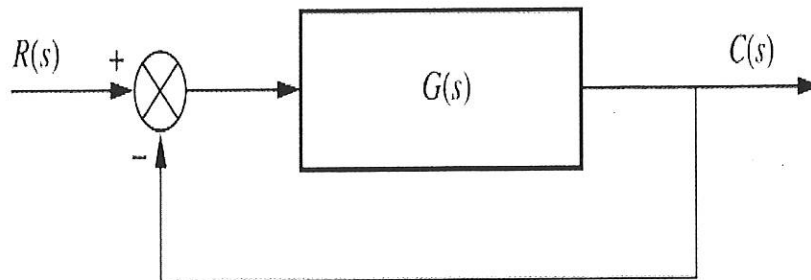　　(d) (5%) find the breakaway and break-in points.

Fig. 4

5. (20%) In Fig. 4, let $G(s) = \dfrac{25}{s(s+1)(s+5)}$. Design a lead controller to meet the specification with

phase margin 60° by use of frequency response methods.

6. (20%) In Fig. 5,
　　(a) (10%) find the values of K_1 and K_f to yield a damping ratio of 0.404 and a peak time of 0.082sec;
　　(b) (5%) find the steady state error if a unit ramp applied;
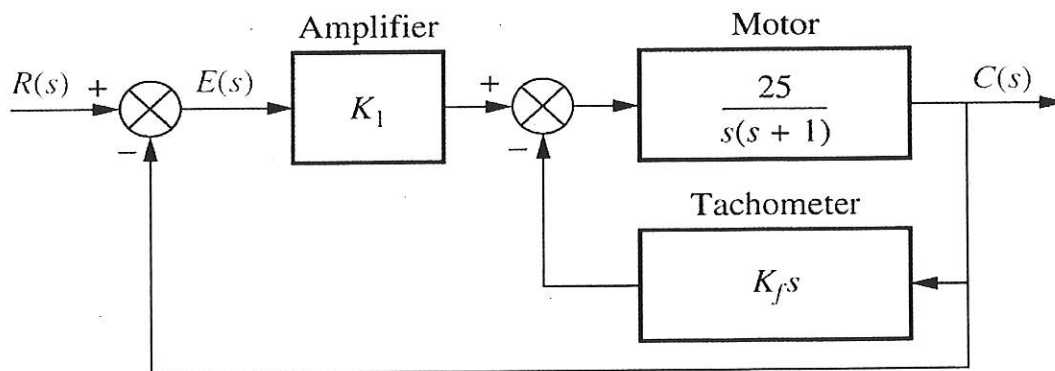　　(c) (5%) sketch the Bode plots for the forward transfer function $C(s)/E(s)$.

Fig. 5

國立中山大學 109 學年度
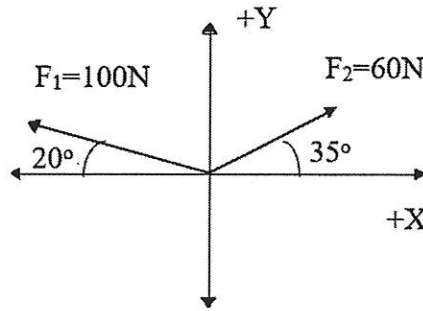# 碩士暨碩士專班招生考試試題

科目名稱：靜力學【機電系碩士班丁組】

1. 如圖一所示 (Figure 1)

Cord BC remains horizontal due to the roller at C, and Cord AB has a length of 1.5 m. If y = 0.75 m, what are the forces in Cord AB and Cord BC for equilibrium of the 200-kg crate? (20%)

2. 如圖二所示 (Figure 2)

Determine x and y components of F_3 so that the horizontal system is in static equilibrium. (10%)
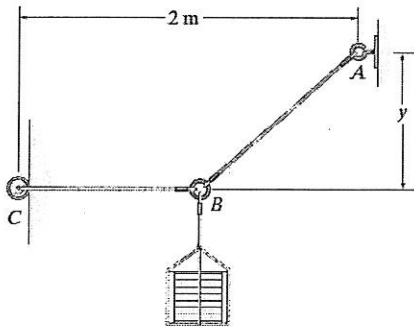
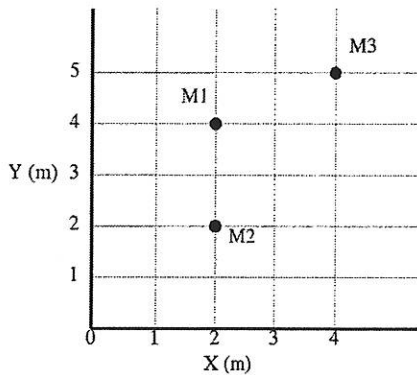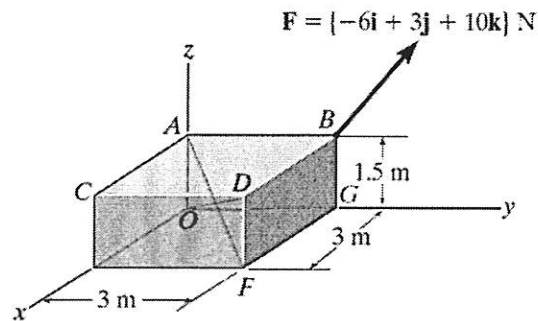圖一 (Figure 1)　　　　　　　　　圖二 (Figure 2)

3. 如圖三所示 (Figure 3)

Calculate the x and y coordinates of the center of mass if M1 = 5.6 kg, M2 = 8.1 kg, and M3 = 2.3 kg. (10%)

4. 如圖四所示 (Figure 4)

Please determine the moment produced by force F about the diagonal AF of the rectangular block. Express the result as a Cartesian vector (20%)

圖三 (Figure 3)　　　　　　　　　圖四 (Figure 4)

試題請隨卷繳回，請留意背面是否有題

5. **如圖五所示 (Figure 5)**

The assembly consists of two red brass C83400 copper alloy rods AB and CD with diameter 30 mm, a stainless 304 steel alloy rod EF with diameter 40 mm, and a rigid cap G. If the supports at A, C and F are rigid, determine the average normal stress developed in rods AB, CD and EF. (20%)

6. **如圖六所示 (Figure 6)**

The drum on the floor has a weight of 100 lb and the coefficient of static friction is μs=0.5. If a=3 ft and b=4ft, determine the smallest magnitude of the force P that cause the impending motion of the drum. (20%)

圖五 (Figure 5)　　　　　　　　圖六 (Figure 6)

國立中山大學 109 學年度
碩士暨碩士專班招生考試試題

科目名稱：動力學【機電系碩士班丁組】

1. A connecting rod is supported by a knife-edge at Point A, as shown in Figure 1. For small oscillations, the angular acceleration of the connecting rod is governed by the relation $\alpha = -5\theta$ where α is expressed in rad/s^2 and θ in radians. Knowing that the connecting rod is released from rest when $\theta = 20°$, determine (a) the maximum angular velocity, (b) the angular position when $t = 3$s. (20%)
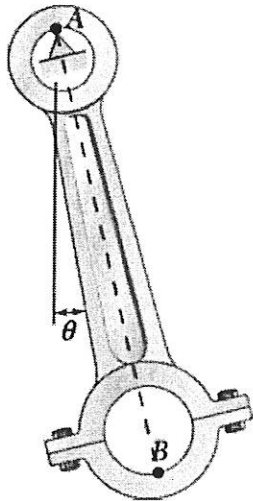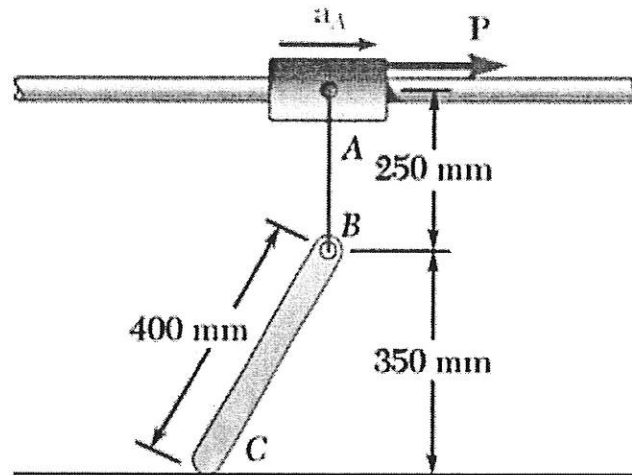

Figure 1　　　　　　　　　Figure 2

2. A uniform rod BC of mass 5 kg is connected to a collar A by a 250-mm cord AB, as shown in Figure 2. Neglecting the mass of the collar and cord, determine (a) the smallest constant acceleration $\mathbf{a}_A$ for which the cord and the rod lie in a straight line, (b) the corresponding tension in the cord. (20%)

3. A 2 kg model rocket is launched vertically from rest with a constant thrust of 50 N until the rocket reaches an altitude of 20 m and the thrust ends. Neglecting air resistance, determine (a) the speed of the rocket when the thrust ends, (b) the maximum height reached by the rocket, (c) the speed of the rocket when it returns to the ground. (20%)

4. A hockey player hits a puck so that it comes to rest in10 s after sliding 50 m on the ice. Determine (a) the initial velocity of the puck, (b) the coefficient of friction between the puck and the ice. (20%)

5. Packages in an automobile parts supply house are transported to the loading dock by pushing them along on a roller track with very little friction, as shown in Figure 3. At the instant shown, packages B and C are at rest and package A has a velocity of 2 m/s. Knowing that the coefficient of restitution between the packages is 0.5, determine (a) the velocity of package C after A hits B and B hits C, (b) the velocity of A after it hits B for the second time. (20%)

Figure 3

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碩士暨碩士專班招生考試試題

科目名稱：科技英文【機電系碩士班戊組】

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1. Please read the following article and answer the question below:

   Virtual Reality (VR) is a computer generated environment that can simulate physical presence in places in the real world or imagined worlds. The user wears a headset and through specialized software and sensors is immersed in 360-degree views of simulated worlds.

   Augmented Reality (AR) supplements the physical environment with computer-generated sensory input such as sound, video, graphics, or other useful information, essentially overlaying digital information on top of the physical world. Some consider the popular smartphone game "Pokémon Go" a form of consumer AR: It enables gamers to find digital characters in the real world.

   Mixed Reality (MR or XR) attempts to combine aspects of both VR and AR. Through merging the real and virtual worlds, new environments and visualizations are generated wherein physical and digital objects co-exist and interact in real time. The virtual objects (holograms) are anchored to points in real space, making it possible for the user to treat them as real.

   Please translate the following terms into Chinese **(3% for each)**
   - (A) Virtual Reality
   - (B) environment
   - (C) immersed
   - (D) simulated
   - (E) physical world
   - (F) digital character
   - (G) visualization
   - (H) co-exist
   - (I) anchor
   - (J) interact in real time

2. Translate the following two sentences into Chinese: **(10% for each)**
   - (A) Mobile robots can examine cables and pipes underwater, snake through small pipes and sewers, fly along electricity transmission lines, and look for small defects in wind-turbine blades high off the ground—among other things.
   - (B) With a drone, everything is recorded, time-stamped and geo-referenced, and that information is there as part of a permanent record of that facility.

3. Read the following article and fill in the correct "preposition" (介係詞) **(3% for each)**

   In 2017, the New York investment firm Lazard released an analysis of grid-scale energy storage technologies, based __(A)__ their levelized costs, which includes both capital and operational costs. Lazard focused on a subset of commercially available technologies capable __(B)__ being deployed __(C)__ a variety of settings, ruling out pumped hydroelectric and compressed air storage due __(D)__ their dependence on specific geologies.

   The analysis looked __(E)__ peaker replacement with lithium-ion batteries as well as flow batteries, where charged electrolyte is stored in tanks. For grid-scale peaker replacement applications, Lazard found no technology to be a clear winner. Lithium-ion batteries had a levelized cost of storage of between $282 and $347 per MWh, with costs expected to decrease __(F)__ around $268 pr MWh __(G)__ the end of this year. Flow batteries, both those using vanadium chemistry and those employing zinc, had a wider range of levelized costs— __(H)__ $209 to $413 per MWh in replacing peak generation— which is a function __(I)__ the lower degree of commercialization __(J)__ the technology.

   Lazard expects the cost of lithium-ion batteries to continue to drop by as much as 10 percent annually over the next five years.

4. Translate the following two sentences into English: **(10% for each)**
   - (A) 微機電系統的發展源自於半導體製程技術，可以透過大量製造程序降低生產成本並提高元件性能。
   - (B) 智能醫學就是將人工智慧用於醫學診斷，透過深度學習技術，讓電腦「學習」醫生的醫療知識並模擬醫生的診斷推理。